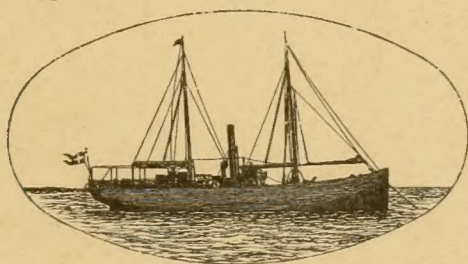




SHOUT
SHARE **IT**

Report
of
The Danish Biological Station
to
The Board of Agriculture.



XI.
1900 and 1901.

By
C. G. Joh. Petersen,
Ph. D.

Translated from **Fiskeri-Beretningen for 1900—01.**

Kjøbenhavn.
Centraltrykkeriet.
1901.



From
The Danish Biological Station.

XI.

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I. The Biology of the Cod in the Danish Seas.

I. Investigations in 1899 and 1900.

In the year 1900 our investigations into the Biology of the Codfish in the Great Belt commenced in the month of March. The very first thing we wanted to know was, where the cod lived in the greatest numbers. On the 27. of March, therefore, we placed 600 hooks in the water, NW of Sprogø, on 4—10 fathoms; they were baited with herrings. After the lapse of 2 hours, part of the line was underrun, but there was no cod on it; the bait, however, was still in proper order, and so we left the hooks where they were. The 28. of March we had a boiler-test on board the *Sallingsund*, and we did not look after the hooks till the 29th. The catch was 29 *cod*, 3 *plaice*, and 13 *common dabs*. We considered this a very poor catch, and set 600 other hooks with herrings, like the former, SE of Sprogø, on 7—24 fathoms of water, down the slope of the deep channel. After the lapse of 3 hours, they were taken up again, and gave 130 *cod*, 1 *whiting*, and some *plaice* and *common dabs*. It was here, consequently, that the cod stayed; they were taken, particularly, on the outmost 400 hooks, and here they would bite immediately, also in the day; it being rather dark down here, with but little difference between day and night. The fishermen never set their hooks at this place, for fear of losing them in the strong current, and on the stony bottom, but more particularly, I think, because they do not know that there are many codfish here, at times, and that the hooks need only stand out 2—3 hours a day; for then all the bait is eaten away. — None of the cod we caught, were under 12 inches in length; most of them were between 13 and 18 inches, and only one was 25 inches long.

In order to learn whether there were no smaller cod out here, we set, on the 31. of March, 600 hooks baited with worms (*Arenicola marina*), at

the same place, SE of Sprogø; for, as it is well known, worms give the smallest cod, smaller than pieces of herring. 115 cod were caught, after the hooks had stood for c. 3 hours; moreover, 85 *common dabs*, 7 *plaice*, and 4 *flounders*. Only 7 cod were under 12 inches in length, and even of these, 5 were about 11 inches; one only was 7 inches, and another $5\frac{1}{2}$ inches. No cod over $18\frac{1}{2}$ inches was caught, as on the pieces of herring. — Small codfish can, consequently, swallow the bait, but two only did so. I take it for granted, therefore, that *there are scarcely any small cod out here*; not, however, on account of these few experiments only, but because it has always proved to be so by the many other experiments I have made, both with hooks and with seines, at this and other places on deep water.

The small cod, on the other hand, were found at Slipshavn, on the 29th of March, on 3—4 fathoms of water, where the fishermen were seining for herrings. In two hauls they got at least 150 pieces between 3 and 8 inches, but no larger cod, or only very few.

The measures of all the codfish, caught in these days, are stated in table I. — They form two distinguished groups. The small ones, between $3\frac{1}{2}$ and $8\frac{1}{4}$ inches, have all been caught in herring-seines, with the exception of two, and all the larger ones on the hooks. *It was impossible to find any cod under $3\frac{1}{2}$ inches in length, anywhere in the whole Belt*. The attempt was made with many different apparatuses, so that I can state with certainty that *they were not found in the Belt at that time of the year*.

The smallest group in table I is the fry of last year (1899), and the large group is formed by the older ones; how old the very largest are, is not known; but those c. 12—c. 17 inches long must be fish that are two years old.

The largest cod from the deep water were spawning; nearly all the males were full of ripe milt, and some of the females of ripe spawn. Not so, however, the smaller ones under 14 inches in length.

In the beginning of April, the waters around Fænø in the *Little Belt* were investigated in a similar way, and moreover with eel hand-seines, with the result that we found rather a large number of cod of last year's fry (1899), of the same size as in the Great Belt; but 600 hooks at Flækøjet, a shallow place with *zostera* in the middle of the current, gave altogether only 43 cod of the older group. The fishermen complained much of the scarcity of cod at this time. Also here the cod were spawning.

On the 18. of April we found, at Sprogø, a quantity of eggs floating in the surface-water, partly eggs of codfish.

As it was here in the Belts, in the spring 1900, with respect to the cod — that there were two distinguished groups, but no fry under c. 3 inches — so it was also in the Limfjord. The same was the case at the said places in 1899, with that difference only that the youngest group was very poorly represented, and could be indicated, indeed, in greater numbers in the Little Belt only. Partly on account of these investigations, partly on



Ctm. c. 66 Inches 25 o

Table I.Total lengths of cod, caught in the Great Belt (Sprogo
and Slipshavn) 29.-31. March, 1900.(The reduction of inches to centimeters is only
approximately correct.)

— 63 — 24

o

o

— 60 — 23

o

o

— 57.5 — 22

o

— 55 — 21

o

Cod of greater age.

— 52 — 20

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ooo

ooo

ooo

oo

— 50 — 19

ooo

ooo

oo

oo

— 47 — 18

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oooooooooooooooo

oo

— 44.5 — 17

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oooooooooooooooo

oooooooo

— 42 — 16

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— 39 — 15

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— 36.5 — 14

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oooooooooooooooo

— 34 — 13

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o

oooooooooooooooo

oooooooo

— 31.5 — 12

oooooooooooo

o

oo

— 29 — 11

o

o

— 26 — 10

— 23.5 — 9

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— 21 — 8

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— 18 — 7

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— 16 — 6

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— 13 — 5

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— 10.5 — 4

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o

— 8 — 3

The fry of 1899.

(The fry of 1900 is missing.)

account of those conducted by the Norwegian naturalists, there is no doubt that, both on the southern shores of Norway and in Denmark, there are every spring two groups, the one year old fry of c. 3—8 inches, and the older fish, from c. 11 inches and upwards; but no fry of 1 and 2 inches — this must come later on, when the spawn, which is deposited in March and April, is developed.

About the tenderest fry of cod, which he discovered and investigated in Lofoten 1864—67, Professor *G. O. Sars* wrote as follows: "Of the young of large codfish I got also, wherever I tried, some up in the net, both such as had lately left the egg, . . ." Further: "Thus, some time after, on a fine, calm day (the 20th of May), I observed on the east-side of Skraaven, in the shallow sounds and coves, with light, sandy bottom, large numbers of them in the surface of the sea." . . . "They were still, as a rule, only 7—8 millimeters, or some 3—4 'lines' long." On the 12th of June he writes: "Everywhere they were seen, from the surface of the water as deep down as I could see, as small, quick, vibrating, darkish threads, eagerly biting at the small species of *Calanus**). They had grown considerably already, the largest being as long as 24 millimeters." — When we know with what primitive apparatus, and with how small boats, *Sars* worked, and learn, moreover, that he could actually see the tender fry of cod in large quantities in the water, it will be understood that it cannot be difficult to find, where it is actually present. I was not a little astonished, therefore, that it was almost impossible for me to find any of it, at any time of the year, during the two years, 1891 & 1892, when the Biological Station was at Fænø, although our situation was so fortunate that we could fish day and night with nets, which were much larger, and fished much better, than those which *Sars* used, and though, in the spawning-time in the Little Belt, I had seen masses of floating, fecundated spawn of codfish, which we could hatch on board after it was caught. I wrote therefore in Report III, p. 5: "It is one of the facts that have astonished me most during these researches, *that the fry of pelagic eggs, which were sometimes found in such huge numbers in Fænø Sound, was not hatched there or, at any rate, was only to be found there quite exceptionally.*"

And this was the case not only with the cod, but with all species of fishes which have pelagic (floating) eggs, in contradistinction to those that deposit their eggs on the bottom. The fry of the latter is, as a rule, easily found. — I can now extend the above statement: it holds good of the said fishes in all Danish seas within the Skaw, with few exceptions, viz. some of the flat-fishes. Particularly with respect to the *cod*, it is certain *that its tender fry is always exceedingly rare in Danish seas.*

Most of our seas have afterwards been investigated, with a view to the result from Fænø; and I have of late years (1899, 1900) looked everywhere

*) Small crustacea.

for the small young cod, but never found any till the end of July, and in greater numbers not till the beginning of August. They are then already from 1—4 inches long, generally at least 2—3 inches, *and can no more be called tender fry*, as they can swim well and, in spite of the current, stay where they like*). In 1899, on the 12th of August, at Fænø, as many as 59 specimens of these somewhat larger young codfish were thus caught in a haul of a quarter of an hour, with eel-seine, on zostera bottom; but this number was unusually large, for nowhere have I seen them so numerous afterwards. The narrows of the Little Belt, on the whole, seem to be a favourite dwelling-place for these little fish, as for several other animals which are carried far to the north by the current. In the seas north of Funen and in the Great Belt, on the other hand, I got, in 1899, only very few in each haul, if, indeed, I got any at all. — The picture (fig. 1) shows how a young cod looks, about half a year old. Except in colour, it has in all respects the appearance of the larger cod. But the colours are grouped, in a characteristic way, in dark and light spots on both sides of the body, so that the fish gets a checkered appearance. This has already been described by *Sars* and pictured by *Hjort*, whose picture, however, seems to me to be less satisfactory.



Fig. 1. A young cod, about half a year old.
(A little larger than the natural size).



Fig. 2. Fry of cod, just hatched.
(A little larger than the natural size.)

To give an idea of the size and appearance of the quite tender fry, just hatched from the eggs, I add figure 2. The young are here represented a little larger than their natural size. The large yolk-sac on the stomach and the 4 or 5 black spots on the body characterize these quite young stages.

To be quite sure that I had not somehow overlooked the tender fry, the investigations were repeated in 1900; but the result was that no tender fry was found and that, of the fry of the year, none at all was living in the Little and the Great Belt till the month of August, and now, moreover, in much smaller numbers than in 1899, viz. at most 2—3 in the haul. On the other hand, the following group (the fry of last year) was much more numerous than the corresponding group had

*) By the extensive gathering-in of plancton which, for two years, has been carried on at ten stations in the Danish seas, every fortnight all the year round, very small young cod, just hatched from the egg, have been gathered; but their number is very small, nay exceedingly small in proportion to the number of fecundated eggs which are found in our seas. On the whole, the young of pelagic eggs are very rare in these collections. In proportion to the number of pelagic eggs which are gathered in — amounting to many

been in the previous year. In the Limfjord, however, we found, in August 1900, not a few young ones, $1\frac{3}{4}$ — $3\frac{3}{4}$ inches long. They seem to have entered the Fjord quite suddenly, while we were staying there; for in the first days of August we found none; but when we returned home, on the 14th of August, we took many in Livø-Bredning. During our voyage, from the mouth of the Limfjord to past Grenaa, we made two hauls, on zostera bottom, in the Aalborgbugt; here too we found the fry of cod, respectively 4 and 6 specimens in each haul. After our return to the Great Belt, it was impossible to find more than a few specimens.

Although these little fish, where they are found, are very easily caught, just as other little fishes, e. g. whittings and gobies, of which we have sometimes got several thousands in one haul, with an eel-seine or ammodytes-seine, we caught, in the whole of the year 1900, in spite of all searching, only 145, 106 of which were taken in the Limfjord. Of larger codfish, however, we took c. 3000. In 1899, c. 1700 larger codfish were caught, but only 340 specimens of the fry of the year; of the latter no less than 170 were taken at Fænø. Of course we might easily have caught many more, both small and large cod, if we would have carried on our fishery for a longer time at the places where we found many, as the fishermen use to do; but we rather endeavoured to investigate as many places as possible and immediately leave every fishing-ground when we had seen its stock of fish. Therefore, the figures quoted give rather a good idea of the scarcity of the fry in our seas in general, more particularly when we remember also, that it takes only $\frac{1}{4}$ — $\frac{1}{2}$ hour to make a haul with an eel-seine which catches the small fry, while it takes long preparations to fish the large codfish on hooks.

I have hesitated long before I have ventured to pronounce the following fact: *from the time when the eggs of the cod are deposited, in February, March, and April, and till the month of August, the fry of the cod is missing in our seas. It then reappears, and although scarce, it is not equally scarce every year, with an average length of 2—3 inches; but the intermediate stages, which Sars so easily observed in the Lofoten, are, as it were, unknown with us.*

As to the dwelling-place of the fry in May, June, and July, nothing is known for certain; but I think it must be looked for somewhere in the North Sea, and I remember pretty well from 1897, when I was trawling a

thousands — they are much rarer than *Apstein* found them to be in the North Sea, on his three expeditions in 1895. (See *V. Hensen und C. Apstein: Die Nordsee-Expedition 1895. Wissenschaftliche Meeresuntersuchungen. Neue Folge. Bd. II. H. 2. 1897, p. 52.*) In a later work this matter will be more closely discussed.

It would be almost impossible to imagine that such quite small, young cod should never have been found in our seas, where fecundated eggs of codfish, at times, are floating about in great numbers, eggs which can be hatched with the greatest ease when they are gathered in. Well, now they have been found; but they are so exceedingly rare — altogether 20—30 specimens — that this fact strikes me as a very remarkable thing.

good deal in the Skager-Rack, on deep water, that a few young codfish were then sometimes found in the seine — e. g. north of Cape Skagen, on 70 fathoms, July 15., 3 specimens. (See Report IX, p. 13.) These finds astonished me very much at that time, but when we compare them with the results of the latest Norwegian investigations, which I shall now mention, they are no longer so inexplicable.

According to *Hjort* and *Dahl's* "*Fiskeforsøg i norske Fjorde. 1899*", we meet in Christianiafjord, and perhaps on the southern shores of Norway in general, a state of affairs with respect to the occurrence of the fry of codfish, similar to that which we meet in the Danish seas. The conditions do not seem to be exactly alike every year — but I shall quote their own words (loc. cit. p. 76). "From April till October we were unable to find the fry, of any stage, in greater numbers. Even in 35 succeeding hauls, in a flat bay (Frognerkilen), we got only 7 codfish of a size of 7,5—11,5 cm (some of which perhaps were the fry of the year), and in spite of a very intense fishery, we got no better hauls in the fjords till the month of October. The fry of the year must be said, therefore, to be very scarce. A similar scarcity of fry was thoroughly ascertained by us in the Christiania and Trondhjem fjords, and we found it most likely that the same was the case with respect to the whole of South Norway, east of Lindesnæs. For want of time, however, we were unable in details to draw the exact limits within which the fry occurs."

"On the other hand, we found great multitudes of the youngest fry, at all the places we investigated in the western and south-western parts of Norway, by the open sea. We could catch here as many as a hundred of these little codfish in every haul with a small eel hand-seine." — Page 79: "In the beginning of the autumn, when the fry is c. 9 months old (in October), it occurs in the fjords." —

In the fjords and east of Lindesnæs, consequently, the fry of the year is very scarce till October, although the cod sheds also in the fjords here. The fry, therefore, must migrate a long way along the Norwegian shores, just as it must in our waters, for its proper home is *only by the open sea*; not till October can it reach into the Christianiafjord. 1899, however, seems to have been an especially good year for the fry of cod, both in our seas and, according to the investigations of *Wollebak*, in the Christianiafjord; for already in the month of May 1899, he found not a few of the fry of the year at *Drøbak*. It is very likely, also, as the currents of the sea have not the same power and do not go in the same direction every year, that the occurrence of the fry of the codfish may vary too. How great the variations may be, time will show.

In 1900, however, *Hjort* has followed the migrations of the fry of the cod farther away, on board the new Norwegian vessel *Michael Sars*, which is especially built for such investigations, and in "*Aftenposten*" of the 26., 27., and 29. of January, 1901, he tells us that the fry of cod can live free

in the water, far from the bottom, as "pelagic fish". He has on the deep sea, between Jan Mayen, Beeren Eiland, and Norway, in *the surface*, found rather considerable numbers of *cod* and *haddocks*, belonging to the fry of the year, as many as 69 in one haul, with a net especially adapted for it of c. 21 feet in diameter. He states, as the result of his investigations, "that the fry of the codfishes, in summertime, is found pelagically in the open Skager-Rack, the North Sea, and the Norwegian North Atlantic, as also on the shores of the open sea; while the deep fjords are, nearly all of them, exceedingly poor in the fry of the year, which is carried along, mechanically, by the sea-current." —

My above-mentioned finds of the fry of cod in the deep Skager-Rack must therefore be looked upon, perhaps, as I was immediately inclined to do when still on board, in that way, that the fish have got into the trawl while the latter was being hauled on board, and the fish have been swimming in the very mass of water far from the bottom; therefore my addition, loc. cit.: "Perhaps under jelly-fish", which does not allude to any mere pelagic way of living, which was then unknown to me. Sars's earlier accounts of the relation between the jelly-fish and this fry are all, we know, based on investigations close to the shore; that the fry should be able to live many miles out at sea, is a thing which Sars has scarcely thought possible. The later investigations do not seem at all to confirm the existence of any closer relation to the jelly-fish. The fry, for instance, is often found where no jelly-fish are living.

In an essay by *M'Intosh*: "Contribution to the Life-Histories and Devel. of the Food and Other Fishes. XV Ann. Rep. Fishery Board f. Scotland. P. III, 1897, p. 194—210. 3 Plates", he gives us some observations on the fry of cod, haddock, and whiting. He emphasises here the great difference in their ways of living between the fry of cod and that of haddock. The fry of the latter always keeps "in deep water offshore", which has been shown by *Fulton* also, till they are nearly half-grown fish. The fry of cod, on the other hand, goes in to the shore when small, though most likely the majority of them also are fond of "offshore waters", till they have reached $\frac{1}{2}$ — $\frac{3}{4}$ inch in length; but then they approach the shores. At all events, however, it is not quite easy to distinguish sharply between "inshore" and "offshore" waters, and, more particularly, it is not easy to use these words in speaking of the Danish seas. Most of our waters inside the Skaw must probably be classed among "inshore waters". We do not indeed, near Scotland, find anything corresponding to the slightly saline (2—2½ p.ct) surface waters (0—c. 7 fathoms deep), which we have everywhere in the Cattegat and along the shores there. In Scotland the nearly unmixed water from the Atlantic goes far into the firths and up to the very surface, and produces "oceanic" conditions in bays and coves, while our fjords are always filled with Baltic water of low salinity. On the shores of Bohuslän and the southern Norway, the Baltic water also forms the surface water, and from

this reason it seems that the fry of cod, on the younger stages, do not occur in greater multitudes at either of these places.

The results of the investigations on the shores of Norway, in Scotland, and in Denmark, consequently, agree with one another as well as possible, and we cannot doubt their correctness, however strange it may seem that the cod, certainly, spawns in our seas, although its fry is not found here for several months after the spawning-season. The *explanation* of this fact must most certainly be looked for in the natural conditions caused by the salinity and the currents. The latter carry the eggs away from the inshore-waters, before they are hatched, at any rate before the young are so large that they can resist the current, and are able to remain at a certain place in spite of the same. Such currents, going out of fjords and shore-waters, have now been pointed out by *Hjort* and *Dahl* in Norway, and we know that the southern current is predominant in our seas through the whole spring. It must be this current which carries the eggs and the tender pelagic fry out of our seas; already in 1892 I supposed this to be the explanation of the disappearance of the fry from Fænø. — How the fry again comes into our waters from the sea, in the month of August, is another question. It is, however, scarcely fry of the same eggs that have been laid there, which then returns; for we must suppose that the eggs are carried by the Baltic current through Skager-Rack up west of Norway, perhaps; but the currents which arrive at our shores in August, come from the southern parts of the North Sea and carry along, probably, fry of the North Sea cod.

What I know, at present, of the fry of the cod in the North Sea, is not much. We have tried several times to find it off the western shores of Jutland; through Thyborøn, we have gone out trawling in the neighbouring waters, on board the *Sallingsund*, as also in the steam life-boat *Vestkysten*; but we never found a single young cod on these expeditions, though we sometimes found the fry of whittings in multitudes. In 1899, Mr. *Chr. Levinsen*, M. A., explored the western shores of Jutland, looking for the tender fry of cod near land, at places especially adapted for it. At Esbjerg he found some of the fry of the year. At Hirtshals thousands of young whittings were taken, but very few young cod — 3 altogether. At Klitmøller he got none; but between Lild-Strand and Bulbjærg, where there was vegetation, he got a number of them, mostly 3—4 inches long. Among the sand-banks on the open shore, he tried some hauls with a hand-seine, but here he found only the fry of plaice.

The conditions near land, on the western shores of Jutland, were, consequently, not very different from those within the Skaw, with regard to the frequency and the size of the fry of cod. Certainly, the bulk of them must live somewhere else. — Among other things, to get an opportunity of investigating the fry of codfish in *Scotland*, I made a trip over there together with the Norwegian Dr. *J. Hjort*, in 1899, in the month of July, and obtained permission to use the fishing-steamer *The Garland* for four

days, for the purpose of these investigations, for which permission I hereby thank *The Fishery Board for Scotland*. As we did not know, however, where the fry was to be found, the days passed quickly in looking for it only. Not till late on the last day, when we had worked our way far westward among the islands west of Scotland, consequently near the open Atlantic Sea, we took the tender fry of codfish, mostly of *the green cod* and *the pollack*, whose fry I never saw in Denmark, but also *8 small cod*, the smallest of which were only a little more than one inch in length.

I had no doubt that I was here near the dwelling-place of the tender fry of the cod, but unfortunately *The Garland* was no longer at our disposal.

The fry of the cod in Denmark, however, scarcely comes from the western shores of Scotland, rather from the eastern shores of England, where the fry is also living; but most likely, I think, we must look for it, *pelagically, in the North Sea itself*. As yet, however, nobody has looked for it here; the idea did not present itself till *Hjort* proved that rather large multitudes of fry can live far from land, and far from the bottom.*) Moreover, it does not seem to be the tender fry only that can live at these places in the water, for *Hjort* has also caught a few cod, as long as 35 inches, on fishing-lines, on great depths of the sea. —

We have now followed the cod through the first year of its life, as well as it can be done in the Danish seas, and have seen that the fecundated spawn, which is shed in the spring, disappears, and that the fry does not begin to appear in numbers till August, when the fish is 2—3 inches long. We have seen, further, that this fry in the next spring, consequently when it is one year old, has reached a length of 3—8 inches, and at that time is to be met with near land, on the *zostera* bottom, along our shores and in our fjords. We shall now follow this group through its after-life. We found it, as above mentioned, in herring-seines, at Slipshavn, in March & April 1900, and stated that it was not to be found then in the deeper parts of the Great Belt. In June, several may still be found at Slipshavn, but some have then gone out on the deep. For out there we now get, on the hooks, not a few cod, as small as 7 inches in length, while in the month of March there were only 2 under 11 inches in length. They have also grown not a little, and continue to grow through the whole summer. In the autumn 1900, the smallest fish of this group were c. 7 inches, and the largest had already amalgamated with the older group, so that it was difficult to distinguish between them. Though thus, certainly, an emigration of small cod is going on in the summer time, from our shallow waters to the deeper parts, more particularly from the waters which are intensely heated by the sun, consequently the shallowest ones, this migration is not of long duration; for already in September, nay, at a few places even in the end of August, when the nights become longer and dark, the

*) Mc. Intosh, however, mentions the finding of one (loc. cit.).

cod come in again. They are evidently fond of our shallow little waters, which are so rich in food, and only leave them when the heat and the light become too intense. Everybody knows that the cod-fishery in the fjords rests during the whole summer, and is carried on only at a few deep places with many currents, as for instance in the deepest parts of the Little Belt, at the Isle of Hjelmen, etc.; as also that the trap-fishing on low water becomes very active, as a rule, in September. This is, no doubt, owing to the above mentioned migration from the low water out to the deep water, and afterwards to the reverse migration from the deepest regions inwards. It is as well known, however, that the frost in winter can drive the cod out of the fjords in the course of very few nights, so that the fishermen, sometimes, can get a good catch of codfish in traps during the emigration; but all these migrations, most likely, are of rather a local importance only, and not of any very great extent; though in such long shallow seas as the Limfjord, they must extend over several miles. At certain times of the summer this fjord is almost empty of cod; but every autumn so many generally get in through Thyborøn, and go past Aalborg, that the fishermen can catch some 200,000 Kroner's worth of cod every winter. The rich fishery in this fjord is remarkable, when we remember that every cod, plaice, and eel, most likely also every herring and many other fishes that are caught in there, must go in through its narrow mouths, either as small or large fish. These mouths are so narrow, indeed, that we might easily close them with some fishing-apparatus and thus catch all the fish, if not the strong current made it impossible. This seems to me a clear proof of a great predilection among the fish for entering our little seas, which are so rich in nourishment; in spite of all hindrances they go in there to find their food. To breed in there, however, is generally impossible for them.

The cod in our seas, however, makes also other migrations than the above mentioned shorter ones. It must not be imagined that all our codfish immigrate into our seas as small fry, a few inches long, to grow up there and remain there for ever. On the contrary. There is no doubt that great multitudes of half-large and very large cod go in here, every year, from the North Sea. This immigration commences already at the same time as that of the fry. But just at midwinter time it seems to become very lively; then the large cod of 20—30 lbs. arrive in the Little Belt, for instance. — Just at that time also the large cod arrive on the Norwegian shores.

In the autumn many other fishes also immigrate into our waters, more particularly such codfishes as at other times do not occur at all in the Belts, e. g. *pollacks* and *whitings*; nay even the *haddock* will pretty frequently go far into the Little Belt and, it is said, in some years into the Sound. With respect to these fishes the immigration is easily proved, because they are generally quite missing in the Belts the whole summer. I shall here remind the reader that the *herring-fishery* in our seas within the Skaw becomes

lively in the beginning of autumn, or already in the month of August, in the years when this fishery on the whole is carried on to any greater extent. This, indeed, has not been the case of late years; some herrings, however, have come every year, and just at this time. I must suppose that these herrings come from the seas outside the Skaw, and do not stay with us continually. To be sure, I have formerly held another opinion on this question, because the herrings in the Belts are smaller than the herrings in the Cattegat; I thought this must necessarily indicate that we had to do with local races. This difference in size, which no doubt does exist, may be explained, however, in other ways also, which do not necessitate the theory of the herring's great attachment to its native place. But I shall dwell no longer on this question*); I just wanted to point out the fact that an immigration of many various species of fish into our seas, is going on every autumn, an immigration which is evidently connected with the pouring into the Cattegat of certain masses of water (the "bank-water"). The same has been pointed out before already by *Otto Pettersson* with respect to Bohuslän, and by *Möbius* and *Heincke* with respect to the western part of the Baltic.

This migration, which is repeated every year to a greater or smaller extent, but regularly at the same times, is known also from the western shores of Jutland. Here cod and haddock are absolutely missing in the summer, but in the winter, when the weather does not prevent it, they are eagerly fished for. Evidently, we have to do here with a very great and general migration of fish, encompassing the shores of North Europe, the closer study of which must be left for future, international investigations.

When, according to the above, part of our cod immigrate as small, and grow up in our seas, while others, half-grown as well as large ones, immigrate yearly, and none, or next to none, live through their whole life in our seas, then it is a logical consequence, that *the cod in our seas, on the main, must be looked upon as a small part of the North Sea cod-tribe, which does not exist independently.* They must be "children" of the North Sea cod and,

*) In Germany it is particularly Professor *Heincke* who has advocated this view, that the herring does not migrate far. But his proof of it — the occurrence of local races — is not satisfactory, a fact which has been pointed out also by Professor *V. Hensen* in "Wissenschaftliche Meeresuntersuchungen. Neue Folge. Bd. II. Heft 2. 1897. p. 76". For the local races may very well be maintained and formed, even if the herring annually migrates far, when it only returns again to its native place, says *Hensen*. He refers to the birds of passage, e. g. the stork, which every year undertakes long migrations, but which knows nevertheless to return to the same nest; for all that, we may very well speak of a special Scandinavian race of storks, and perhaps also point out anatomical peculiarities in it. The possibility that the fishes can possess a similar local sense, is not at all excluded; more particularly as it seems that we have found indications of it, e. g. by labelled salmon. These questions must be solved, as usual, with respect to the fishes, by direct investigations in the open nature, just as they have been solved with respect to the stork.

therefore, cannot differ from the parents in other respects than those, which may be produced by their being "brought up" in another sea. Not only does this become a necessary consequence, but all our cod must be brothers and sisters; it must be impossible to point out different races of them in our seas.

We seem here to have come to a result, which is at variance with many well known facts and with the views of many authors on this point. *G. Winther*, for instance, writes in his *Prodromus*: "That the cod, in spite of its seeming swimming-power, is a fish that is but little migratory, is seen from its many local varieties, and from the difference there may be in regard to plumpness, taste, and appearance between codfish that are caught at places situated near to one another, but very different with respect to natural conditions and animal life". Nevertheless he maintains that there is but one species of cod with local varieties. — *H. Krøyer* also speaks of different varieties, but he does not seem to be disinclined, for that reason, to believe in the longer migrations of the cod; and he was a man who had much opportunity to study the cod, both here and in Norway, though, certainly, only on land. — Of later accounts of the varieties of the cod, may be mentioned those of *Dannevig*, in Norway. He maintains, with great force, against the above mentioned investigators *Hjort* and *Dahl*, that the cod is a very local fish; for he can distinguish clearly between local races among them. Till quite lately there has thus been, and is, dissension in this matter, and this dissension has led to rather a sharp controversy, because it is a matter of great practical interest. For, if the cod in the Danish or the Norwegian fjords is stationary — and it must be so, if we can point out racial characters, which it keeps through its whole life — then the fishery legislation must be changed accordingly, and a careful protection together with artificial hatching must be introduced in these fjords. But, if the cod is not stationary, the hatching is of course meaningless, unless we will try to carry it on, on such a large scale that the whole North Sea and, if possible, the Norwegian North Atlantic too, may be expected to profit by it — and this, of course, is practically impossible. In Norway *Dannevig* has now for several years carried on hatching on rather a large scale, and it will be understood that he has at the same time done all to ascertain the occurrence of local races of cod. The characters on which he thinks here more especially to be able to take his stand, are the *differences in colour* among the cod. It is a well known fact that the cod, on a bottom which is overgrown with reddish plants, can be quite red or yellowish red, so that it approaches in colour very much to a red burnt tile; but if the bottom, even at quite a short distance, has another colour, greyish or greenish, the cod that are caught here, are greyish or greenish. If, therefore, cod which have once become red, cannot become grey or greenish when they change their dwelling-place, they must be very local indeed, and long migrations,

consequently, cannot take place. *Dannevig*, now, is of opinion, that he has observed in his salt-water reservoirs, that the colour of the cod remains unchanged, even for several years, both that of the red and that of the grey cod; but he ends nevertheless by saying: "There is another way to the goal, which is both shorter and safer." — "What is more reasonable then, than that he provides himself with a light, grey deep-sea cod and a red "Taretorsk", and then changes the colour of the former into red, that of the latter into grey?"

I must acknowledge that *Dannevig* is right here. This is the safest way to solve the question. As the experiment, as far as I know, has not been made before, and as I had just in the Great Belt great facilities for getting cod of a very red colour, at Refsnæs, out on the algæ-bottom, I took, on the 25th of May 1900, a number of these red cod on board, and kept them alive in a tank with fresh-streaming water till our arrival at Korshavn at Fyens Hoved. Here half a score of them were placed in a cod-trap, the entrance of which was closed, on a greyish zostera-bottom. They were left quite to themselves till 1. June. The trap was then taken out of the water, and all the cod were now grey, so that nobody who had not seen them before, would have observed anything particular in their colour. On the border of the lips and on the fins, however, some had still a faint reddish tinge. That also this would have quite disappeared at last, there is no doubt. The experiment has afterwards been repeated in the tanks of the Biological Station. There we kept red cod for a somewhat longer time, and at last every tinge of red disappeared from them. Of course, we might as well have made grey cod red, by removing them to a red bottom; but, partly, this is not so easy to do, as the red bottom is to be found only here and there on deeper places with many currents, so that it is no easy matter to place a trap in the water, partly, I consider it to be quite superfluous — and so does Dr. Hjort — especially now after the above experiment has been made, with the most extreme differences in colour, because such changes of colour in fish is a thing everybody who works with living fish has often the opportunity of seeing, and they are easy to understand when you know the histology of the skin. The red, yellow, and black colour-cells are always there, and the changes of colour only depend on, whether the cells are more or less contracted. They may be contracted into quite small round points, whereby the corresponding colour almost disappears; particularly when, at the same time, the cells of another colour have sent out their ramifications, so that these cells, branching forth in the form of a star, spread their bodies, and thereby their colour, over a proportionally large area. All this may easily be seen, on every cod, by means of a strong microscope; *Dannevig*, however, mentions also another so-called race-character, which is independent of difference in colour, viz., the different lengths of the shore-cod and of the North Sea cod, when they become ripe

for the first time. *) The cod on the shore often shed already while they are rather small — 9 inches, says *Dannevig*. But the North Sea cod is considerably longer before it sheds, c. 20—22 inches. If I am not mistaken, *G. O. Sars*, in Norway, has also already called the attention to this phenomenon, and explained it in a similar way as *Dannevig*, as an indication of the existence of special fjord-races. I myself can state that the cod often sheds in our Belts, when it is 14 inches long, and perhaps still smaller. But to state this fact is a very different thing from declaring these codlings to be a *true race*; to do so, it is necessary to have proofs. Such, however, I do not know at all. Suppose a man takes a sack of quite homogeneous grain, of wheat, barley, or any sort of corn, and sows it in different places, part in fertile soil, part in poor soil. Though the offspring here are brothers and sisters, consequently of the same race, the corn turns out very differently in the different places; but we are not entitled to call the thin, short corn in the poor fields another race than the fine corn in the fertile fields. It is only external conditions which have produced individual variations, distributed in groups, “external races”, which disappear when the grain is sown again in another soil. Something more is wanted to form a true “internal race”; it must not so easily lose its racial characters by transplantation. But I shall enter no further into this question of races which is of such a great importance in nature. I only wanted to point out that the cod in the fjords and shore-waters, although they do not in everything agree with the cod in the more open seas, very well may be their direct offspring, and the children of the latter, nay, perhaps themselves become North Sea cod when they grow older. For these differences, as we have seen, may have been produced only by change of dwelling-place (the colour), and therefore be very variable, and all of them may perhaps quite disappear when the fish grow older. At any rate, before we can believe in particular fjord-races, we must be able to point out their fry and to show their whole development in the fjords — and this is just what we cannot do. If such races really did exist, we must also be able to point out certain characters which were independent of age and dwelling-place; but all such attempts, since the time of Linné, have failed. — In order to check the results of these biological investigations, in some measure, I tried to find out, whether any difference could be pointed out in the number of rays in the fins of the cod in the Cattegat and that in the North Sea. The number of

*) Different colours of the spawn of the cod, to which *Dannevig* refers as a race-character, are, in Hjort's opinion, of very little consequence, as the colour is dependent on the various contents of fat in the eggs or the milt, and these depend very much on the food which the fish gets, both as to quantity and quality. The fat contained in the food, according to the latest physiological views, goes directly into the organism without changing its chemical combination. Moreover, the colour of the spawn does not keep in the hatched fry, so that there is scarcely any reason to attach any importance to this whole matter.

these rays is, in the cod, subject to no small variation. In the Great Belt you may thus in the first dorsal fin count, now 12, now 16 rays, generally however 13 or 14. The number of rays in the second dorsal fin varies between 15 and 22, and in the third between 15 and 20. In the first and second anal fin there is a variation of respectively 16—23 and 15—19. When a cod has become 1—2 inches long, and perhaps already before, this number of rays does not change any more in it; it is consequently independent of age, dwelling-place, and, as it seems, also of sex. As the number of the rays, as I have said, is subject to no small individual variation, it would, in analogy with what is known from other species of fish, be quite likely that this variation and its limits would not be the same in different races of cod. If there were, e. g., one race in the Cattegat and another in the North Sea, it might probably be seen by an examination of the number of their rays.

So all the rays were counted in 76 cod from the Great Belt and 25 from Esbjerg, and the result was for

1. dorsal fin in the Great Belt as a rule	13—15,	at Esbjerg	13—15 rays,
2. — - —	—	17—20,	— 17—20 —
3. — - —	—	17—19,	— 17—19 —
1. anal - —	—	17—21,	— 17—21 —
2. — - —	—	16—18,	— 16—18 —

consequently so exactly alike that I very soon gave up finding any difference in race on that point.

Besides the characters the zoologists have tried to use as marks of different races of the cod, I have heard others mentioned by the fishermen, of which, however, some might be said before-hand to be no characters of race, but only signs of the fish being more or less fat, or of quite individual variations. One of the more striking circumstances to which my attention was called, was that "some cod have a tongue, others have none". I have never been quite able, however, to discover the difference between fish with and without a tongue; for the phenomenon, certainly, depends only on the manner in which the cod opens its mouth when it dies. Sometimes the tongue protrudes far in the mouth, sometimes it lies pressed down and is less visible. Krøyer has also known this, but like myself he attaches little importance to it.

Another, more remarkable, thing is that the cod in certain waters north of Funen is almost always infested with the well known worms in the flesh (*Ascaris*).

Worms, certainly, may be met with at all places and at all times of the year; in the Great and the Little Belt, however, there is not one out of a hundred cod which has worms. But in the above mentioned waters, at Endelave and west of Samsø, according to the fishermen's statements, nearly every cod is infested with them; and not with a few worms, there are many

in every fish. They are not to be seen externally, but when the fish is gutted, it is easy to find the worms; and these cod are such a bad article of commerce that "you can never sell that sort more than once at the same place" — then people know about it.

When I arrived at these parts this year (20th Octbr.), 13 cod from a fishing-boat were examined, and they were nearly all, particularly near the anus, but also in the parietes of the abdominal cavity, to such a degree infested with worms that they could not possibly be used for food without loathing. I have formerly shown that the herrings in the neighbourhood of Goteborg are also more infested with worms (*Ascaris clupearum*) than those at other places, c. 25 p. c. of the full-grown herrings having got them, while I found only c. 17 p. c. at Lolland, and none at all at Bornholm. Now, certainly, we do not know at all how quickly the stock of fish in a sea can be infested with these parasites, but when they have got them, they certainly keep them for some length of time. These cod must therefore remain in nearly the same places for rather a long time, and I should think that just these infested cod are those which immigrate into our seas when small, and stay there till they are 2 years old. There will then be time enough for the worms, which must be particularly fond of the said waters, to be developed and to "infect" the whole stock. The cod I examined were all about 2 years old. There is nothing here to prevent these cod from emigrating to the North Sea afterwards and become "large cod"; for in these the said worms are not rare, even though not all of them are infested as in the said waters.

Of the *age-groups* of the cod, and of its *growth* in general, I have said something above. We are acquainted with its growth in the two first years, in which it reaches an average size of c. 14—15 inches (35—40 ctm.) (see above p. 5, table I), and becomes, in part, mature; but the higher ages we do not know very exactly. *K. E. Earll* (U. S. F. C. Report for 1878, Part VI, 1880) mentions 4 groups of cod between 0 and 22 inches, but he has given no proof of them. Nor has *G. O. Sars* given any proof, by measuring the fish, of the correctness of his estimate as to the growth of the cod; and it is my opinion that he is wrong in his estimate; they do not grow so quickly as he supposes.

H. Krøyer, who has seen so many cod in the Lofoten, states one of the very largest to be 54 inches long; but that must have been a veritable giant. The common Lofoten cod ("Skrei") are generally but 30—40 inches long, and so large are also the full-grown North Sea cod. Many cod of the same size are also fished in our waters in the winter. Yet they are not by far so frequent here as those whose measures are stated in table I. In table I we reach only 25 inches; we have, consequently, not at all to do with full grown cod, properly so called, for these I suppose, as I have said, to be between 30 and 40 inches. How the cod between 30 and 20 inches (see table I) are grouped, I do not know; probably there is here an age-

group which is most frequently missing in our seas. Were I to form an *estimate* as to the growth of the cod, it would be as follows: In its first year it is between 1 and 8 inches long; in its second between 10 and 18; in its third between 20 and 30; and in its fourth year 30 inches and longer. After that it grows but slowly. In our waters it is the one and two years old fish that form the main body of the stock; the tender fry and the older ones (3 and 4 years old, and more) are rather rare within the Skaw. — Compare *Fulton*: "19. Annual Rep. Fishery Board. 1901", in which a somewhat similar growth is reported of the cod from Scotland, but with the same uncertainty with respect to the older fish. Over there the cod as a rule does not become procreative till it is 20—22 inches long.

According to *John Bickerdyke*, the sportsman (Sea Fishing. London 1895. The Badminton Library), the views held by the English fishermen as to the size of the cod, come somewhat nearer to mine; for they call cod under 20 inches "codlings", between 20—30 inches "sprags", then follow "halfcod" and "cod".

It must be considered as proved that, even though there be some difference with regard to colour, early maturity, and average size, between our cod within the Skaw and the cod in the North Sea, they both belong to the same stock of cod; they both make migrations every year, from one sea to the other, the fry as well as the larger fish, and to such an extent that our domestic stock of cod cannot be destroyed till that of the North Sea is destroyed; for even if all cod in our waters were fished up, they would very soon be replaced by an immigration into these seas from the North Sea.

II. Investigations in 1901.

The above treatise was in all essentials finished by me in the spring 1901; but I did not want to publish it till later on, as I hoped in the following year to be able to supplement it on several points. This hope has been realised, and I shall here add what I have further learnt in the course of this year with respect to the life of the cod in and near our seas. It has fallen to my lot this year to take part in two expeditions on board the Norwegian scientific steamer "M. Sars", by whose chief, Dr. *J. Hjort*, I was invited. On the first of these expeditions we went from the Lofoten to the Norwegian North Atlantic, Hammersfest, and Spitzbergen, our principal object being the investigation of the fry of the cod. With Dr. *Hjort's* permission I can state, on the basis of our investigations in Norway this summer, that my view on the question is as follows: that *the tender fry of the cod*, some time after the hatching and till it is at least 5 cm. long, *has its home in the open sea in the summer*, partly far from land, and not in the fjords; it does not arrive here till later in the year. We fished great quantities of it near the surface, and it was the prey of the immense shoals of

green-cod on the western shores of Norway. — This was in the month of July 1901. When Dr. *Hjort*, in September 1901, on my invitation, went to Skager-Rack in his large and good ship, in order to supplement my investigations into the occurrence there of the fry of the cod, we found *no pelagic young cod*, however, *in the whole Skager-Rack*, but fry of whiting and horse-mackerel (*Caranx*), whereas some fry of the cod was found on the bottom, already somewhat larger. Nor did I find pelagic fry of cod of any consequence in the Skager-Rack, in June 1901, when I was on board the *Sallingsund* (only one specimen, 1 inch long), but much fry of whiting and a little of haddock; so it is to be supposed that the limit of the distribution of the pelagic fry of cod must be drawn from South Norway over towards England somewhere. Pelagic fry of whiting, however, from $\frac{1}{4}$ inch (c. 1 ctm.) and upwards, was found as far down as in the Great Belt. This was the first addition to the investigations this year, but there is one more, which is as essential, respecting the migrations of the older cod in our seas. The Cattegat has repeatedly been investigated this year, with the *Sallingsund*, the first time in the month of June. My result, arrived at by questioning the fishermen at the Skaw, by seeing the Swedish fishermen draw long lines on Groves Flak and Fladen in the eastern Cattegat, and by setting long lines myself, *was that there were exceedingly few cod in the Cattegat and Skager-Rack in this month*. Some few smaller cod might be got at Hirtsholmene on zostera bottom, but it was only at one single spot; at other places 600 hooks, baited with herring and worm, gave only 6, 10, or no cod at all. — Swedish fishermen maintained with certainty that there was no cod now from Hanstholmen to Sweden; they could only get a few whittings.

In August and September 1901 the Cattegat was again investigated and, with Dr. *Hjort's* assistance, the Skager-Rack. The Swedish fishermen in the eastern Cattegat now got a few more cod on their long lines and many small haddock. We found the same with trawl at the Skaw and in the northern Cattegat. The cod, however, were always small, and only at one single place (at Hirtsholmene, as in June) we found more considerable numbers of them. Fry of whiting was found pelagically, as it were, always, everywhere, and in all sizes; but fry of cod only upwards of 2 inches (c. 5 cm.) at the bottom and very rarely. Near the Skaw, on c. 20–30 fathoms of water, it was most frequent.

These investigations have taught me that *the Cattegat at times (in the summer) can be almost empty of cod, at any rate of large, good cod*. To get the precise data I applied to the Inspector of the Fisheries within the Skaw. It appeared then from the journals at hand, of 1898, 1899, and 1900, that c. 30 plaice-seine cutters in the Cattegat had stated, for each fishing, how many pounds of cod they had caught, which figures might be extracted from the said journals. Lieutenant *Ewald*, R. N., who gave me this information, was kind enough to extract the necessary data from the many

(c. 90) journals, for which I beg to express my best thanks. These cutters are fishing particularly for plaice, and therefore use their seines in the same way, and chiefly at the same fishing-grounds, all the year round. When they do not catch any cod, the reason is, therefore, that there are none, and the table on p. 23 shows from this reason, approximately, the number of cod in the Cattegat in the various months of the year. We see immediately how frequent the cod is in the winter half-year, especially in January, February, and March, and how rare it is in the summer. I must here call attention to this, as another proof of the fact that the great multitude of cod leaves the Cattegat every year in the summer, and returns in the coldest months. — The Great and the Little Belt, however, do not become as empty of cod every year as the Cattegat. When we know how long the water at Samsø and in the Belts, on the deep, can keep its winter temperature — much longer than that of the Cattegat — it is not surprising that a great number of cod remain here through a considerable part of the summer, nay, perhaps all the summer, while, as above mentioned, good cod are exceedingly scarce in the Cattegat at this time of the year. The way from the Cattegat to the North Sea, certainly, is also shorter and easier to find. — *Earll* (loc. cit.) mentions how the shark (*Squalus acanthias*), consequently just our common Dog-fish, on the shores of North America is the worst enemy of the cod. It remains there from May till September; the shoals devour everything, drive the cod away, and put a stop to the fisheries. This reminds us very much of the conditions on the western shore of Jutland and in the Cattegat (see Report X, p. 33). Perhaps these sharks are of far greater significance in the household of nature, than we are generally inclined to think. As yet they have not been systematically studied in our seas, but in 1901 Mr. *H. Lorentzen*, the fish-exporter, of Frederikshavn, informed me that he had now for two years been commissioned to get sharks for the University, for Professor *H. Jungersen*; but in the winter it had been impossible for him to deliver any: the first did not arrive till the month of June every year. When we know how regularly the fishery at Frederikshavn is carried on with the same apparatus all the year round, this is an excellent proof that the shark is missing in the Cattegat in the winter. It is a fact, however (see Report of the Biol. Station X, p. 33), that some “winter” in our southern seas (analogous to the “summering” of the cod); but, on the whole, the shark must be said to be a summer guest in our seas, as shortly mentioned also by *Winther* in his “*Prodromus*”.

A third important addition to our knowledge of the cod has also been obtained this year, viz. *that no fry of the cod was found this year at Bornholm*. In spite of all searching with seines and hooks, and in spite of dynamiting where the fishermen thought the fry must be, none at all was found. *I must suppose that the tender fry of the cod cannot thrive at all in the whole Baltic Sea*, and that all the cod which, in considerable multitudes, are fished as far north as Finland, have immigrated into these parts through

Cod-fishery in the Cattegat in the years 1898, 1899, 1900

with plaice-seines from c. 30 cutters.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1898.....	221	126	306	94	8	„	„	10	$\frac{1}{2}$	46	101	114
1899.....	188	178	91	26	8	$\frac{1}{2}$	„	„	5	6	62	132
1900.....	262	250	442	77	„	„	„	„	46	5	110	57
Average for the 3 years.....	224	181	280	66	5	0	0	3	17	19	91	101

The figures state "*the number of pounds of cod per fishing-expedition*" or the proportion between the total weight of the cod caught in one month and the number of fishing-expeditions in the same month.

the Danish seas as small or middle-sized fish. Dr. *Th. Mortensen* has conducted these investigations at Bornholm this year, on board the *Sallingsund*; a report of them will be published later on. That all the Baltic cod have immigrated through the Danish seas, seems to agree very well indeed with Dr. *R. Lundbergh's* account of the fisheries in the Baltic Sea ("Royal Commission on Trawling". App. p. 464, 1885) for several fishes, among which were cod and dab. The fish will be quite common there in certain years; but suddenly they disappear from the sea for years, and he is unable to give any reason for it. When everything depends on an immigration through the narrow Belts, it is easy to understand that the winds and the currents, which are so changeful, in one year can further, but as well in other years can check the immigration. The stock therefore becomes very different in the different years, particularly in the inner parts of the Baltic. On the whole, the stock of fish with pelagic eggs in the Baltic Sea is most likely dependent on an immigration from the Cattegat, and there are scarcely many species that manage these long migrations so well as the fry of the eel seems to do. —

We see then the cod in Denmark at various times of the year undertake long migrations, and on different stages of its development stay in different seas. *G. O. Sars* in his well-known "Indberetninger" has just the same view of the cod on the shores of Norway. He meant to have proved that the cod bred in the Lofoten every winter, but nevertheless the same fish was living in the summer far northward, in some years as far north as Spitsbergen. It now seems as if these theories of his will come to life again. But when our cod leave the Cattegat they do not, at any rate, go to the Lofoten; they rather, I should say, go to the North Sea, the Faroe Islands, and Iceland. But at present I know nothing of this with certainty.

II. On Other Codfishes in our Seas.

Besides the common cod, we have as above mentioned a number of other codfishes in our seas, whose migrations and biology it may be of interest here to compare more closely to what I have stated above. The *haddock* is so rare in the Belts that, during the three years in which the investigations have been carried on by steamer from April to November, both included, I have caught, and seen at the fishermen's, in all, only one single specimen. The Little Belt fishermen mention it as "the light cod with a black spot on each side", but they do not know its name. It appears in the Little Belt in certain winters only, consequently as a veritably migratory fish, which is not at all at home in the Sound or the Belts.

The haddock is said to have been frequent in the Sound in certain years, many years ago; but now there has not for many years been any fishery for it there. In the Issefjord, where no haddock is found now, there must in the stone age have been many of them; for in the kitchen-middens at Solager a great many bones of haddocks are found among the other remains of meals, and the people of the stone age must no doubt have caught the fish near the place where they have eat them, consequently in the Issefjord.

In the Cattegat, on the other hand, the haddock is found in the deeper regions on the soft bottom. It is most frequent in the winter half-year. Its fry is generally not found in the Cattegat in large numbers; only a few specimens have been taken in the northmost Cattegat on a depth of 20—30 fathoms, and in the Skager-Rack on 70 fathoms, as also a few pelagic ones.

For the present time at least, the haddock then occurs in the Cattegat as a visitor only, and it does not breed there. It prefers the deep water — much more so than the cod — from which reason it does not enter our fjords at all. This holds good also of its fry.

The *whiting* is much more frequent in our Belts than the haddock, and sometimes goes far into the Baltic Sea. But in the summer it seems to have regularly disappeared from the Belts. Not till sometime in the autumn it appears again, at the same time as other fishes pay their visits. In the northern part of the Cattegat we caught rather young whittings (of 2 different years), often hundreds of them in each haul with an otter-seine, the whole summer through; most frequently on 20—30 fathoms. Large whittings were taken in the Skager-Rack only. The fry of the year I have often seen in the Cattegat, e. g. under jelly-fish, and as far down as the Great and the Little Belt. — The whiting is evidently a very migratory fish; in its first years it often roams the waters pelagically, entering the Cattegat in huge multitudes, and being carried, accidentally, a shorter or longer distance into our other seas. The large, full-grown fish seems, as I have said, in the summer to be found on deep water only, outside the Skaw; but in November 1900, when I set 600 hooks in the deepest part of the Little Belt, from Fænø to Jutland, we caught 9 cod only, but 12 whittings, several of which were 15 and 16 inches long. — As to the age and growth of the whiting, I can say only as *Wollebak* (see "Report on Norwegian Fishery and Maritime Investigations", vol. I. 1900. Nr. 1, Chapt V, p. 114) that it is difficult to distinguish between the fish of the various years by measuring them, although we can easily get the fish in great numbers. The different shoals evidently must grow very differently, according as the natural conditions are favourable or unfavourable. I must also agree with him when he says that it lives in shoals, that it is not attached to the bottom when it is young or half-grown, and that it is a very migratory fish. When the whiting comes here in the autumn, there is another codfish which generally comes at the same time, the *pollack* (*Gadus pollachius*), but it comes in much smaller numbers, and I never saw its fry in Denmark. In 1900, in October and November, I saw some specimens of this fish in the Great as well as in the Little Belt. Interesting is H. Krøyer's statement that he once, in May 1834, saw 600—700 pollacks be taken in a pound-net at Fredericia. I never saw so many. — The other fish in our seas, nearly related to the pollack, the *green cod* (*Gadus virens*), does not so often, however, go into our smaller seas; nor did I ever see the fry of that fish, although I have seen smaller specimens, of c. one foot's length, at Frederikshavn.

Neither the pollack nor the green cod breed in Denmark; they are rather rare here, and come as visitors only, with more or less regularity, into our seas. In the deepest part of the eastern Cattegat I have in former years caught green cod on hooks in the midst of the summer.

The fry of the green cod, on the other hand, is found in numbers on the shores of Norway, west of Lindesnæs, where it may be taken in hundreds in every haul with a Danish eel hand-seine. It lives here on low water, particularly where the bottom is overgrown with *Chorda filum*, together with

fry of the common cod. Also the fry of the pollack is found here (*Hjort*). For the present I shall say nothing of our rarer codfish on deeper water in the Cattegat, *Gadus minutus*, the *hake* (*Merluccius smiridus*), and the *ling* (*Molva vulgaris*). There remain then of codfish only the *rocklings* (the genus *Motella* (*Onos*)) and the *paddock* (*Raniceps vulgaris*). Among the former we meet the peculiarity that it is easier to find the fry in our seas than the grown up animals. This is not the case with the paddock. The grown up animals are always caught singly only in our in-shore waters. In the deep Skager-Rack, on 70 fathoms, I have, on the other hand, taken as many as 7 *Motella cimbria* in one haul with an otter-seine. The grown up fish, however, are as I have said otherwise so rare that it is, at present, impossible to enter more closely on their biology. As they, most likely, spawn later in the year than the other codfishes, consequently when the currents lead into the Cattegat, this is perhaps the reason why the fry is so numerous here.

When you have for some years been studying flat-fishes: plaice, flounders, dabs, etc., as I have been doing, and then sets to work upon the codfishes, you soon feel that the latter are much more inconstant. The investigations must be carried on in quite another way. If, after some time, you return to a fishing-ground you have formerly investigated, you often find everything changed, the fish have gone, and you do not understand anything of the whole matter, till some day the explanation flashes upon you: migration and migration and once more migration. Our seas within the Skaw are small, not longer than many Norwegian fjords, about which we know now, that they are, at times, filled with cod, and at other times quite empty of them. It lies near, therefore, to suppose that shoals of cod at certain times enter the fjords, and that they leave them again at other times; particularly so, as we have long known that other fishes such as garfish and mackerel do the same. — When we have seen, on the shores of Norway, how the green cod in immense shoals, at the utmost rocks, chase various "Aater", and how it goes far away from the bottom on these hunting expeditions, often scouring the sea with their fins above the surface of the water, so that this is all in a foam, while the seiners who are on the watch, must row out their seines with the greatest possible speed, if they want to catch part of the shoal, then we can understand also that the cod, the near relation of the green cod, though not so swift a swimmer, very well may undertake long migrations, and that it is not at all such a dull bottom-fish as it has sometimes wrongly been said. Nay, Dr. *Hjort* has even proved, that large cod can live pelagically out in the surface-waters of the Norwegian North Atlantic, over the great depths, whose temperature at the bottom is below zero, so that it is impossible that the cod can here have anything to do with the bottom.

But while *Hjort* feels convinced "that these fish in large multitudes migrate over the great depths", I must, as matters are now before us, rather doubt the

correctness of this view, if it is his opinion that the cod, as a grown-up fish, during certain periods of its life, should live normally, in the very body of the water in the open North Atlantic.

As yet it is not many cod and haddocks Hjort has met with out here; and the few finds I have myself seen on board his vessel, gave me the idea that they were possibly stray individuals which, as it sometimes happens with migratory birds, had reached places where they were not at home at all. The haddock that was caught in the Norwegian North Atlantic while I myself was looking at it, was certainly a very large fish; but it was lean, and did not look as if it felt quite well out there. I speak here purposely of cod and haddocks only; that the "Uer" (*Sebastes*), as Hjort has pointed out, is common, pelagically, in the Norwegian North Atlantic, is, I think, beyond any doubt. Perhaps I am mistaken in my view; time will show, I suppose. At any rate I quite agree with *Hjort*, when he says that the cod is a fish which undertakes long migrations, so long that the distances in our seas are but short in comparison with them.

III. Some General Observations on Protection, Legislation, etc.

In 1852 the Norwegian government appointed a committee for the investigation of the fisheries in Christianiafjord and Langesundsfjord, in which, among others, Professor *H. Rasch* had a seat. Our own great Danish fishery committee of 1873 writes about this gentleman, that he was a "discerning Norwegian naturalist, whose life-work it has been to endeavour to develop and maintain the natural resources of his native country by legislative and administrative regulations". There can be no doubt that Professor Rasch's views have highly influenced those of our own committee, much the more so as the latter, to its great regret, was unable to make any investigations in open nature and, consequently, must rely exclusively on earlier works on the life of the fishes, which were of little value for practical purposes. The Danish fishery committee quotes the following passage from the report of the said Norwegian committee: "Whether a fishing-apparatus or a fishing-method *may be supposed**) to injure the fisheries, depends particularly on, whether the vegetation on the bottom of the sea and the spawning which takes place here are disturbed by the same, as also on, whether a greater number of fish are damaged or destroyed without becoming of any use to man. By disturbing the vegetation on the bottom of the sea, we deprive most species of fishes of their best breeding-grounds; further, we deprive the smaller fishes of their hiding-places, where they go to escape from their pursuers, and we destroy also a multitude of little animals, which serve as food for the fishes, and which live on or among the sea-plants."

*) Italicised by C. G. Joh. Petersen.

Starting from these preconceived opinions, *Rasch* maintained "that seines which are dragged along the bottom, are very injurious apparatuses, and ought to be forbidden in Christianiafjord", and more particularly that they are more injurious than others, such as hand-lines, pound-nets, traps, and the like. No doubt, it is also from these considerations, in addition to their own individual points of view, that the Danish committee had got such a firm belief in the great injury done to the stock of fish by ground-seines and similar apparatuses, and therefore recommended, 1) *absolutely to forbid* the use of certain sorts of these seines, and 2) to allow the use of others only outside certain "*closed waters*". It should be mentioned distinctly that Professor *Chr. Lütken*, the only naturalist who was a member of the committee, was very sceptical about these points of view, particularly as to the necessity of the closed waters; but as it was impossible for him to conduct any investigations to clear up the matter, he must content himself with this negative standpoint. He points out the fact, however, that, in the mean time, *G. O. Sars*, another Norwegian naturalist, had proved that many salt-water fish, such as codfish, do not deposit their eggs on the bottom, as *Rasch* supposed them to do, but that the roe floats or swims in the body of the water, and is hatched there, consequently quite out of reach of the apparatuses that are dragged along the bottom.

In 1888 the motion of this Danish committee became law in Denmark, though certainly in a much altered form, and it is but natural, therefore, that the views of the committee have, to a high degree, influenced opinions and views in Denmark. Of these views there is particularly one which has for many years, had a great influence on my ideas, viz. "that the fjords are not wrongly considered to be of particular importance as favourable spawning-grounds for certain species of fishes, and as rearing-places for their fry". The words "*particular importance*" and "*favourable spawning-grounds*" should be especially noticed; but, to be sure, the committee says only "*certain species of fishes*"; we are not told which particular fishes are meant.

There can be no doubt that, if the regulations of a law of fishery as to the protection of the fish, are not based on the correct foundation — *that which agrees with the real conditions in the world of the fishes* — then they will not bring about the desired results. If we believe, for instance, that the stock of fish has been destroyed by a certain way of fishing, and therefore forbid the same, the stock of fish will not be better than it was before the prohibition, unless it is *really* this certain way of fishing that has destroyed it. The fishery legislation in several countries affords striking examples of this, and they are very instructive.

Thus, presumedly in consequence of the Report of the above mentioned committee, ground-seines were forbidden in Christianiafjord, in 1870, because they destroyed the fry, etc.; only floating seines for herrings and mackerel were allowed. In 1893, *G. M. Dannevig*, the well-known Norwegian

fishbreeder, of Arendal, writes as follows (*Morgenbladet*, Nr. 532 & 536): "What the common way of protecting — some few and insignificant restrictions, while the main-business is going on without let or hindrance — leads to, is clearly shown by the state of things in Christianiafjord where, in spite of the protection, in the course of 20 years, the catch of mackerel, flat-fish, cod, and other species of fishes, has dwindled in to a small fraction of what it has been". I shall further state, that they commenced, in 1892, to place artificially hatched fry of cod in Christianiafjord — so bad was the stock. The prohibition against ground-seines seems thus to have been rather powerless with respect to advancing the growth of the fry. On the other hand, it cannot be denied that there is now, in the zosterafjords near Christiania, an exceedingly rich stock of eels, which nobody seems to fish. In a Danish hand-seine, which I tried up there, in 1896, under the ægis of Dr. Hjort, we could fish as many eels in every haul as in the most "closed" waters of the Limfjord.

Of late years the fishery conditions of Christianiafjord have now been subjected to a renewed and thorough investigation in open nature with many different fishing-apparatuses. (See: *Fiskeforsøg i Norske Fjorde*, 1899, by Dr. Joh. Hjort, Superintendent of the fishery investigations of the Norwegian government, and Knut Dahl, M. A., Fellow of *Videnskabselskabet*, Trondhjem). In this excellent work, which is so rich in new observations and new points of view, it is proved that *Christianiafjord is not at all a spawning-water, much less a spawning-ground of any importance; the fry lives in other places on the shore out by the open sea*. We understand therefore that the prohibition against ground-seines was without any visible results with respect to the growth of the fry of fish in general. If the authorities will, and if they can, do something do develop the fishery in Christianiafjord, it must be by something else than prohibitions against ground-seines.

There is also, of recent date, another still greater experiment in legislation, which is of great interest, viz. the English *prohibition against trawling in certain of the larger firths and bays of Scotland*, some of which are almost to be considered as parts of the North Sea. In 1886 all trawling was prohibited in these firths. In other words: they were "closed" against all trawling. During the following 10 years *The Fishery Board for Scotland* examined the state of the stock of fish at various times of the year, by means of a steam-trawler, *The Garland*. It was expected, of course, that this prohibition would produce a rich stock of fish in these waters. But Dr. Fulton states that, *neither in the closed nor in the open Scotch seas, was there, after the lapse of 10 years, any striking increase of the stock of fish in general to be seen*. Among the flat-fishes, *plaice* and *lemon dabs* had decreased in number, while *common dabs* and the *long rough dabs* had increased; and this was the case both in the closed and in the open waters in Scotland.

This result shows then that it is not everywhere sufficient, in order to

gain our end, to prohibit trawl-fishing; for *if there be not a breeding-ground within the closed water, where the fish will remain*, either all its life or at any rate for years, it will emigrate from the closed water, and will then be caught. Now it seems just to be so in Scotland, says *Fulton*, that *common dabs* and *long rough dabs* breed in closed waters, but *plaice* and *lemon dabs* go out of them, and breed farther out at sea. — If we in Denmark would close Aalbæk-Bugten, within a line Cape Skagen—Hirtsholmene, against all flat-fish fishery, I suppose the same thing would happen with the plaice; there would not be many more, than there are now, and they would not grow longer than they are; for they would emigrate to Læsø and Herthas Flak before they grew large. It has been said that the best way to promote the offshore fishery is to protect the inshore fishery, for the fry of the plaice comes from the inshore waters; and the best way to promote the inshore fishery is to protect the offshore fishery, for the large plaice come from the open sea. This would be correct, of course, if we could at all consider inshore fishery as the opposite of offshore fishery. — If it had been correct, as it was formerly supposed, that an apparatus which was dragged along the bottom, and before all the large English trawl, destroyed the food of the fishes on the bottom, the discontinuance of the trawl-fishing in the Scotch seas for ten years must indisputably have caused a very great increase of the food of the fishes, and, no doubt, a multitude of fish would then have gone there from neighbouring, unprotected places. As this did not occur, however, I am confirmed in my opinion *that the ground-seines are not so detrimental to the food-animals as it has been supposed*. In the Limfjord where seines of different sorts are dragged across the bottom in great numbers, and at very different times of the year, certainly many times across the same area every year, we are not aware of any destruction of the fish-food; at any rate the plaice thrive and grow here better than at most other places in our seas. The opinion has even been expressed that ground-seines (eel hand-seines) will positively be useful by removing the *zostera* at those places where it grows too richly.

In the report of the last English government committee, 1900, of a sea-fisheries bill, they do not speak of any destruction of the lower animal or vegetable life caused by the trawl, still less of any destruction of the spawn; and though the committee distinctly maintains "that it is proved beyond doubt that there is a very serious diminution of the supply of certain kinds of flat-fishes, particularly in the North Sea", it only mentions as one of the causes of this decrease: "It is quite certain that the destruction of fish below a certain size is an evil". This is a thing we can understand, and this is a thing the English investigators have been able to show, that the immense multitudes of little flat-fishes which the trawlers catch, and which have no value, or next to none, are lost to the North Sea, and that, if such a destruction can be avoided, we have gained an advantage which will get a great influence on the produce of the fishery.

How this advantage is best to be gained, by which legislative regulations, the commission dare not say before further inquiry and investigation have been made. The commission could imagine various ways by which to obtain it: *directly*, by a prohibition against the *fishing and killing* of such little fish, or by *prohibiting all fishing* at places where such little fish live; *indirectly*, on the other hand, by prohibitions against the sale of fish under a certain size. The latter, they suppose will induce the fishermen to avoid such places where the small fish live.

The committee seems to be most inclined to go the latter way; but this too leads to various difficulties, particularly when the length of the fish is to be positively decided upon.

The width of the meshes of the trawl is not mentioned at all by the committee; I think, with justice. By this way, which formerly was so popular, nothing can be gained in the North Sea, at any rate only very little.

In short, the same principles of protection and legislation are laid down in the Report of this English committee, as in Report IV of the Danish Biological Station, with respect to the flat-fish fisheries of the Cattegat. It is also this latter report on which the first witness of the said committee, the Chief Inspector of Fisheries to the Board of Trade, bases his views on these questions. (*The growth-theory — the breeding-theory.*)

The views on the main principles of the fishery-legislation concerning these matters have thus been completely changed; and at the same time great progress has been made also in another respect. We know now that it is not sufficient any longer to speak of fish and fry of fish in a general way; we must mention the *particular species of fishes* for the fishing of which we want to legislate, as well as those which we will leave to their own resources. We have known long that we must have other game-laws for woodcocks than for partridges; we know now also that, what holds good of the birds in this respect, holds good also to a certain extent of the fishes.

Just because it is so necessary to distinguish clearly between the different species of fishes, on account of their exceedingly different conditions of life, it may be appropriate, perhaps, here to give a short view of them. This view pays particular attention to the occurrence of the fishes in the Danish seas within the Skaw. It has not been possible to give it till now — and then even in rough outlines only — after the Biological Station has had the S. S. *Sallingsund* at its disposal for three years; but hereby it has been enabled to investigate large areas, at various times of the year, and to make sure of the movements of the fishes in the course of the year.

With respect to their occurrence in our seas within the Skaw, the fishes may be divided into two main groups:

- I. *Stationary fishes*, which live all their life in our seas. —
- II. *Migratory fishes*, which do not live all their life here, but at certain times stay either in the North Sea, Skager-Rack, or in the Baltic Sea. —

It will be understood, however, that the very same species of fish may sometimes be classed with both of these groups, as some of its individuals will always remain with us, while others will sometimes emigrate. About this, more, later on. —

The **Stationary Fishes** are again to be divided into several groups:

a) Stationary fishes in the fjords or, at any rate, within Danish territorial waters. They are closely attached to the places where the *zostera* grows. They deposit their eggs on *zostera*, stones, or similar things, or they are viviparous.

Of more useful fishes belonging to this group is to be mentioned only the *eel-pout*; but there are also the *gobies*: *Gobius niger*, *G. flavescens*, *G. microps* (*G. minutus*?), various *pipe-fishes*, the *fifteen-spined stickleback* (*Spinachia*), and *stickle-backs* (*Gasterosteus aculeatus*).

With this group may be classed also two animals that are not fishes, the *prawn* (*Palæmon*) and the *oyster*. We must not forget, however, that the *oyster* lives also outside our territorial limit; but those which live in the Limfjord, naturally, will stay there all their life, though part of the fry, no doubt, may drift out of it.

b) This group of stationary fishes comprises only the *eel*. It lives *nearly* all its life in our fjords, or near our shores, in the *zostera* and in quite fresh water. This fish is stationary with us, from it is a little young one, $2\frac{1}{2}$ inches long, till it is a full-grown silver-eel; which means, certainly, not a few years; but then it leaves our territorial waters and the fresh waters in order to breed, and never to return any more.

c) This group comprises fishes which live, partly in the fjords and partly in more open waters, but which never leave our seas within the Skaw. They have floating (pelagic) eggs, which are generally hatched outside the fjords, on the open shores, where we may also find the fry; that of the *plaice*, the *flounder*, the *turbot*, the *brill*, and the *sole*, on lower water, that of the *dab* on deeper water. It may be supposed that several of these fishes migrate around the Skaw, particularly from without into the Cattegat, and no doubt a great many plaice also go through the Belts from the Baltic Sea up towards the Isle of Anholt. These individuals which thus migrate, ought properly to be classed with the migratory fishes, but, nevertheless, all in all the species plaice must be reckoned among the stationary fishes. It never quite disappears from our waters like e. g. the cod or the herring. We can always, at the right places, find the plaice living in our seas in great numbers all the year round.

d) *Salmon*, *trout*, *gwiniað*, and *smelt* have a peculiar way of living as stationary fishes: they spawn in fresh-water, and live during the remaining

part of the year in salt-water on our shores; nay, the salmon, perhaps, lives even pretty far from the shore, it is not known exactly where. These fishes then migrate within our district, and must be classed with the stationary fishes, as we take the word here.

Of the other fresh-water and brackish water fishes, properly so called, which live in the Baltic at some distance from the shores: the *pike*, the *perch*, and *Leuciscus idus*, I shall here say nothing particular; they are perhaps, in part, to be looked upon as migratory fishes from the Baltic Sea.

The Migratory Fishes may also be divided into several groups:

a) The genuine migratory fishes, *garfish* and *mackerel*, which appear on our shores only for a short time (the former in order to spawn), and which again completely disappear from them before the end of the year. Their migrations are so obvious that they have been known for many years, and have never been misconstrued. These fishes, most probably, live out in the Atlantic Ocean during the winter.

Certain other fishes, particularly the herring and the sprat, ought also, in part at least, to be classed among the genuine migratory fishes; but they may come from the Baltic Sea as well as through the Skager-Rack. The biology of the herring, particularly, is so complicated, because there are different races, with different spawning-seasons, that it is not easy here to ascertain anything precisely. Our seas are never, at any time of the year, quite empty of herrings; but, certainly, in great masses they are found only when a migration takes place from the surrounding larger seas. In spite of all the mathematical science that has been written of the herring and its various races, this question is still very far from being solved; but it *does* migrate; and the Baltic Sea herrings are smaller than those of the North Sea, that is certain too.

b) This second group of migratory fishes comprises a number which, from some reason or other, do not live all their life in our seas. Either the young ones are missing, or there are certain intermediate ages which the fish spends outside our waters, or it makes annual migrations in and out. The *cod* is the most important fish that belongs to this group. Its fry, at certain young stages, is missing, and the grown-up fish goes annually in and out through our seas. In the Baltic and in the Belts, however, not a few remain every year; but, all in all, the cod must be called a strongly marked migratory fish. In a somewhat similar way we must look upon the *haddock*, the *whiting*, the *pollack*, and the *green cod*; only they go still farther away from us. However strange it sounds, the *halibut*, the *pole dab*, and perhaps the *lemon dab*, must also be classed among the migratory fishes. The young ones of all three are very rare, or quite missing, here; and although the two last named of them perhaps do not go far, they go far enough at any rate to disappear from the Cattegat into the Skager-Rack

to the deeper water. Of all these migratory fishes we have thus no regular stock; it must now and then be renewed from without.

This survey contains, in rough outlines, the main results of these last years' biological investigations. Perhaps, in future, some alteration will be made in the grouping of the fishes, and all our other species of fishes of less immediate economical importance must be fitted into it, as the investigations proceed; but the results we have already gained concern the fishery-legislation so deeply that I have been unwilling to wait any longer with the publication of them. It is evident, that it is particularly with respect to the stationary fishes that something may be done, within the Danish sea-district, by means of legislation. When, therefore, the present law prohibits the buying and selling of *cod* and *whittings* under 8 inches in length, this must be considered less appropriate, already from this reason; though, of course, it will always be expedient to spare the fry of cod as well as of whittings, and not to catch them in multitudes for manure or similar purposes.

Of the stationary fishes it is before all the flat-fishes that need protection; but I have discussed these elsewhere, and therefore I shall not here enter more closely into this matter. That the present law protects the *dab* is less necessary, among other reasons, on account of its slight value to the trade; but the *sole* ought to be included among the protected fishes. It is not possible, however, for Denmark alone to make great progress in these matters. I am here quite of the same opinion as Captain *Drechsel*, the Danish commissioner of fisheries, who at the Swedish Fisheries Conference at Stockholm, 1897, said "that the protection of the inshore fisheries will not always answer the purpose, because the propagation of the fish and the hatching of the eggs most frequently occur outside the inshore waters, just at also the great fishery which is of any importance with respect to over-fishing, is carried on at sea. Another thing is that the inshore waters, at any rate certain parts of them, to a great extent seem to be the dwelling-places of the tender fry of flat-fishes, and that it is necessary, therefore, by certain regulations to protect it in these waters.

The investigations in recent times seem thus, particularly, to claim protective regulations for the open sea fisheries, consequently by international legislation." — — —

What Denmark *alone* can do is, therefore, only to prevent the very worst destruction of the fry of the flat-fishes in the open seas, and to protect by law the species of fishes that particularly live in the enclosed fjords or within the Danish territorial waters, *in as far as they are in need of protection*. The species of animals which may here come under consideration are not many: in general, indeed, only, *eels*, *eel-pouts*, *prawns* and *oysters*, *plaice* in the *Limfjord* and elsewhere, *flounders*, as also *trout* and *salmon*, and perhaps the *brackish water fishes* south of Zealand.

The *eel*, no doubt, is best protected by regulations as to suitable minimum sizes at the various places, and as to the widths of the meshes of the eel-seines in the Limfjord.

The *eel-pout* seems to be in need of protection only at very few places, and is on the whole a less important fish.

The *prawn* (*Palæmon Fabricii*), on the contrary, undoubtedly wants protection. (See *Dr. Th. Mortensen's* "Undersøgelser over vor almindelige Rejes Biologi og Udviklingshistorie", published by "Dansk Fiskeriforening", 1897.)

It has been said against this view that, for instance, when the water freezes to the bottom, the stock of prawns may thereby, at certain places, suffer so exceedingly that this alone is enough to explain a decrease of prawns for many years, so that protection is of no use at all, or even injurious; if the water freezes to the bottom, the prawns will die; if not, we shall get a rich prawn-fishery. This argument, however, is not quite satisfactory. It is not in all waters where the prawn lives that "bottom-frost" causes such destruction. It is, undoubtedly, worst in some particular seas (south of Zealand). But even if this decrease of the stock of prawns is caused by the natural conditions, there can be no doubt that a suitable protection, according to circumstances, would contribute much to increase it again. I should rather draw the conclusion that, the more "bottom-frost" there has been, the more it is necessary to protect the prawn. Something like this is known also from the world of game-animals and from the vegetable world.

Finally, it has been said also that the year 1901, with its warm summer, has been such a rich prawn-year at several places, although we have had no protection, that we can draw the conclusion from this fact that protection is altogether unnecessary. This is also wrong. For though we may conclude from this that the prawn-fishery under certain favourable conditions of weather, and as it has been carried on of late years, may be somewhat improved without any protection by law, nobody can say that the prawn was not *in point of fact* protected to a very great extent, at many places last year, *because it would not pay to fish for the few ones which there were*.

No, indeed, there has been protection in recent years at very many places. The conditions of the Limfjord, with respect to these matters, are particularly well known; I shall therefore take that water as an example. In 1899, the value of the prawn-fishery in the whole fjord amounted only to 28,150 Kroner, and Mr. Redsted, the surveyor of the fisheries, moreover, adds the following observation: "The *prawn-fishery* is rather to be considered a failure; for a great part of the income which this fishery shows, is certainly due to eels caught in prawn-traps. The summer of this year was especially good for prawn-fishery; but the prawns did not come."

In 1900, they also fished very few prawns in the Limfjord, without laying the blame upon the weather; but in 1901 there was again some increase.

The following list shows the income on the prawn-fishery since 1891:

In 1891 they fished for 2,965 Kroner.			
- 1892	—	- 9,319	—
- 1893	—	- 14,960	—
- 1894	—	- 118,450	—
- 1895	—	- 129,345	—
- 1896	—	- 79,093	—
- 1897	—	- 34,185	—
- 1898	—	- 19,200	—
- 1899	—	- 28,150	—
- 1900	—	- 31,300	—
- 1901	—	- 70,315	—

When we now know that it was not the fishermen near the Limfjord who discovered the prawn-fishery in 1892—93, and when we learn that the number of fishing-apparatus (traps and nets) rose from 116 pieces in 1891 to more than 2000 in 1896 and 1897, and have seen also how much the traps filled in the fjord, and how many fishermen there were who carried on this fishery, then we cannot doubt that the decrease in 1897 and 1898 was owing to over-fishing. The result was that the foreign fishermen stayed away, and the local engaged in other fisheries, or made *attempts* only at fishing for prawns. *In this way we got an effective protection of the stock in the whole fjord*, and, finally, the good summers also caused the stock quickly to increase again, in some measure, in 1901. But, no doubt, this will not last long. — Now, the question which the legislative power will have to consider, is this: shall we suffer this whole matter to take its own course, suffer the prawn to be over-fished when it begins to come up again, and then for some years let it sink down again to giving some 10—20,000 Kroner in annual income; or will it be better to try, by suitable forbearance, in the good years, considerably to improve the bad years? A total destruction of the prawn, if it is not protected, is quite out of the question; the point is only to get the greatest annual profit on the productiveness of the fjord.

It will never be possible, without experiments, to prove directly how we are to treat the stock of prawns in the best way. Should the opinion prevail that this matter is not yet so clearly elucidated that a legal time within which the prawn is to be protected, may be fixed for the whole country, then experiments can be made on a small scale, just on behalf of the prawn; it is sufficiently stationary to render this possible. I suppose that such experiments can be made, for instance, in the Limfjord or Issefjord. In the course of a few years they would give us certainty, not only as to the question whether protection is of any use, but also as to which method of protection is the most suitable. The thing is certainly worth

some trouble, as the prawn costs 2—4 Kroner a quart; and as it is one of those few animals which remain within the boundaries of our country, so that we can give laws without international negotiations. The *oyster* is another of those animals which have shown that protection can restore the stock in the course of a short time, even though it has been considerably reduced. About this matter, however, I shall say no more, as it is in many respects different from other fishery-questions.

It still remains to mention the fishes which have more or less to do with the fresh water, but which at times live on our shores in salt or brackish water, particularly, the *salmon*, the *trout*, the *gwinia*, the *pike*, and the *perch*. Of these, the fishes that live in brackish water, are but of little consequence from a pecuniary point of view. If we wanted to do anything for them, we must first of all get them protected breeding-grounds, in the seas they resort to. The *salmon*, the *trout*, and the *gwinia*, on the other hand, are more important. The first thing necessary, with respect to their life in salt water, is to get them free access to the breeding-grounds. We have here to do with even very valuable fishes, about which we know that they breed in our waters, in the fresh waters moreover, and only there. Here the breeding-grounds are all within our reach; and all fishing for them is carried on in fresh water, or within Danish territorial waters. (With respect to Bornholm things are different, however.) — Unfortunately the matter is made more complicated with regard to these fishes, by the necessity of a corresponding legislation for the fresh water and the salt water; but in other countries, in Norway for instance, they have succeeded, after all, in getting over this difficulty. —

It has been maintained that the prawn has been protected for a long time already, for instance by prohibitions against seine-fishery in the spring, by closed waters, where all sorts of seine-fishery, "Strygglib", and "Aalekam" are absolutely forbidden; and yet, this has been of no use, as there are fewer prawns now than when the law came into force. From this it has been inferred that protection is of no use at all. Such an inference, of course, is, according to the above, quite groundless. The mistake, as far as I have been able to trace it, has its origin in the fact that the old Norwegian belief in the noxiousness of the ground-seines, and the advantage it would be to get rid of them, is still alive among our fishermen, and has resulted in the "fishery regulations", which they have provided for the various small waters. In by far the greater part of these regulations absolute prohibition against seining ("closed waters"), or prohibition against seining at certain times, is of great importance. Now, such prohibitions may in themselves do much good, as they help to regulate the respective conditions for fishery with fixed and with loose apparatus, a matter which has always been, and will always be, eagerly discussed, as long as both sorts of apparatus are used in the same water; but then the fishing-season must be limited with a view to this matter, and *we must not call such a regulation a protection of the fishes*;

for, whether the prawns are fished up with seines or with traps, or with both, the result will be the same, viz. decrease. — Nay, if we want to protect the fish, and to promote the fishery, we had better aim 1) at getting all migratory fishes free access into our little waters and there fish them, 2) at making it easier for the salmon and trout to reach the breeding-grounds and stay there in peace, 3) at prohibitions against the landing of fish under the size-limit, 4) at protection during a certain time, or “closed waters”, for the prawns in the summer, 5) at transplantation of the fry of flat-fishes into suitable waters, etc.; i. e. we must lend a helping hand to the immigration.

I am glad to see that the size limit for eels, in many regulations, has been extended from 12 to 14 inches. At certain places, however, it is evident that this is not sufficient. It is a good thing also that salmon and trout are now protected in salt water for a certain time, at various places; but, unfortunately, the protection is generally too late in the year, in December and January instead of October and November. In Hobro and Mariager fjords, however, they are protected from 15. October to 15. January, which evidently is a very good arrangement.

By the regulations a way has been opened, at various places, to regulate the fishery in accordance with its wants. Perhaps it would be the right thing to do, by direct negotiations between the Biological Station and the fishermen at the particular places, to try to give the regulations such a form that the fishery was turned to profit in the best way possible. The knowledge the Station now has got about these waters, would then in a more direct way be made useful to the fishermen, than now when they must acquire it through the printed reports, which, besides, cannot be written with an eye to the particular interests of every little district. —

The main result of the biological fishery-investigations is, after all, quite encouraging. The fishes are not so easily *extirpated*, as some people have been inclined to believe. The fisheries can stand, and they have already been obliged to stand, a great deal of less good, not to say bad, legislation, and yet they are not quite destroyed. The principal ways by which the improvements may be made, are known to a certain extent. Whether people will follow them, before or later, is only a question of money. The fishermen, however, have already at many places got their eyes opened to this, and demand, at their meetings, severer punishments for infringements of the law, and sharpened regulations for the protection of several species of fishes. Let us hope now that it will not last too many years before we get the greater profit on our fisheries, which we may expect from a suitable legislation and the local regulations that result from the same. Sharpened regulations with respect to protection, where they are necessary, supported, at suitable places, by the transplantation of fry, and the abrogation of useless restrictions on the fisherman's trade, will be the means of such a legislation.

IV. Alterations and Improvements on Otter-seines for Zoological Purposes.

In Report VIII of the Danish Biological Station, 1898, I gave a description and a picture of an otter-seine, of which I had made use for catching the more quickly swimming animals, such as larger crustacea, smaller fishes, etc. This seine has afterwards been employed by many vessels, larger as well as smaller ones, and has nearly always worked satisfactorily. Of course, the working of it requires more practice than the manoeuvring of an ordinary dredge, as it is next to impossible that the latter can run foul when it is let down. That the seine, however, catches well, is proved by the fact, among others, that it is now used in Norway for the fishing of deep-sea prawns (*Pandalus borealis*). (See, as to this question, Dr. Johan Hjort's essay). In Norway it is called "*Ræketravl*", and is employed by common sailing-boats on 60—70 fathoms of water. According to statement, they fish for 1—200,000 Kroner a year with this otter-seine, on the southern shores of Norway. No doubt, it can fish then. But new hands at it, seem to have certain difficulties to overcome in the use of it: it sticks in too soft a bottom, it does not reach the bottom at all, it runs foul when it is let down, etc.

I have, since 1898, made use of otter-seines to a very great extent; and I have succeeded in making various improvements on them, both as to the construction and as to the treatment of the apparatus. I shall here give information about these improvements, hoping that they may be of use to other investigators. For there are not a few people already who employ this seine. I have delivered specimens of it to Norway, Germany, Russia, Sweden, and Finland; in America they also want to make use of it. Moreover, there are others who have delivered these seines to people abroad, I do not know how many, and perhaps people in other countries have tried

to make them themselves from my descriptions. This, however, I should not advise them to do. The first specimen had better be obtained through myself, as there are a number of little things which are of consequence, but which it is not easy to explain without making the description exceedingly complicated. — The otter-seine has been employed already, so to speak, in all latitudes, in northern and in southern countries, as well as at the equator, and on depths from the shore to at least 1000 fathoms, so it seems as if the apparatus has really supplied a want.

1. The seine sticks in the bottom where the latter is very soft. This draw-back has been felt from the very first, and it is not always redressed by making the foot-rope lighter or by tying divers lighter ropes on to it. Dr. Hjort has in his "*Fiskeforsøg i norske Fjorde*", 1899, p. 33, described a way to avoid that the foot-rope at the arms, and afterwards at the mouth, is dragged down into the clay on a soft bottom, and fills the bag of the seine. Over each stone at the foot-rope he fixes a glass ball, and as the stones are hanging in short straps, the ball will lift the foot-rope, already before the latter reaches quite down to the bottom. This method seems at many places to be suitable. But, as we have learnt that it is the arms which first begin to cut down into the soft bottom, and that the mouth then afterwards is drawn down into it, I have chosen an other means, viz. to cut the arms off the seine, so that only a little stump remains at each board. In this way the same thing is attained. We might imagine that the width of the seine would be much diminished by this, but this is not the case; for the boards must not, even if the arms are rather long, be removed more than 12—16 feet from one another (Report VIII, p. 18). The speed, the length of the crow-foot, and the size of the boards must be suited to this. But we can get the same width by stretching the meshes of the mouth above and below, i. e. by sewing them on to the head and foot ropes, stretched out (See fig. 6. Report VIII, p. 15). The mouth itself thereby becomes somewhat broader, and the form of the seine more similar to that of a common trawl (See fig. 3. loc. cit. p. 8), only that the head and the foot ropes are of the same length. I first got the idea by reading *Dr. P. Schiemenz's* technically excellent investigations on "*Die Zeesenfischerei in Stralsunder Revier*", in "*Abhandl. d. Deutschen Seefischerei-Vereins*", vol. III, 1898. The arms on our otter-seine are only necessary, when we want to catch eels in a rich *zostera*-vegetation; for then they must be able to cut close to the bottom, where the eel lies. On a bottom where there is no rich vegetation, they are consequently superfluous, and the bottom is so nearly everywhere, except in some particularly small, shallow fjords. With such seines without arms I have afterwards fished exceedingly much, also eels, on a bare bottom, and, as far as I remember, the seine has never been filled with clay or mud. Of course, we must not put too heavy a weight on the foot-rope; but we are not tempted to do so either, as the boards,

when they move on the bottom as they ought to, keep it down sufficiently. The fishing-capacity seems, generally, not to be diminished at all by these seines, although we use the same equally large seine-bags; the meshes at the mouth only being sewn on to the head and foot ropes more stretched out, and the arms being almost cut off. There is another rather considerable advantage which we get in this way; the boards, even if they are very large, and even if the crow-foot is somewhat long, cannot now be removed from one another so far that the fishing-capacity of the apparatus suffers from it. The head and foot ropes, stretched square out, will now always keep them in nearly the same distance from one another.

2. In the beginning I had much difficulty in preventing the crow-foot from twisting, because there were turns in the tow-rope which, during the heaving-in, went down into the crow-foot. I tried to prevent this in various ways (see Report VIII, p. 17); but the best way to avoid all twisting is by means of shackles, in the crow-foot as well as by the boards, particularly when there are ball-bearings in the shackles as in a cycle-crank. They are easily made, and work excellently. Add to this that, the more a steel-wire is used, the less of course will this twisting be. In *John Bickerdyke's* "Sea Fishing", London 1895, p. 277 (The Badminton Library), there is a picture of a shackle for an otter-trawl, which will perhaps be still more practical. The arrangement for an otter-trawl, of which he gives a picture, loc. cit. p. 275, is, on the whole, very much like mine; but I have never heard that it has been much used anywhere. The method employed by the fishermen is at any rate different.

3. Many investigators have found it very difficult to make the otter-seine follow the bottom, and if it does not, the rule is that nothing will be fished. This is indeed one of the greatest difficulties in all trawling. For it is often difficult to judge of the speed of the vessel over the ground, particularly when we have no landmark, or when we cannot moor a buoy, and then trawl with this in sight. If we cannot do so, and if no land is to be seen near us, we are very badly off on greater depths. The best advice I can give in such a case is to use heavy boards, the heavier the larger the vessel is, and, before the trawling, to make a haul with a dredge, partly to learn whether the bottom on the whole is suitable for trawling, partly, if possible, to learn something about the direction and speed of the current. Generally the vessels, especially the large ones, go too quickly over the bottom; under such circumstances it is enough for the trawl, if we only move across the bottom either by means of the current and wind alone, or with a little help from the engine. On the whole, seines with small meshes can never bear a great speed; the whole body of the water will then be carried along with, and nothing is caught.

4. Unpractised people have met with difficulties also in lowering the seine, partly because the seine runs foul, partly because they fear that the line shall get into the propeller. The following is the best way of manoeuvring. If the seine is to be lowered starboard, the vessel must have the wind in nearly on the starboard beam. Immediately before the seine is let down, the engine is stopped, so that the vessel keeps some speed ahead; this should not be lost till the seine is so far out that the tow-rope can be caught up in a snatch-block on the quarter of the vessel, abaft the propeller, while the seine is abaft the vessel. You may now manoeuvre just at you like, only the vessel must not go astern, and not lie still; then the tow-rope can never get into the propeller. You now veer away the rope through the snatch-block, the rope constantly pointing somewhat astern. If you have only speed enough, you may veer away much line, if you like, but you must take care that the tow-rope is always taut; afterwards you may slacken your speed, and let the seine sink to the bottom. — When the seine is to be hoisted up again, the line must out of the snatch-block; the latter, therefore, must be constructed so as to be able to swing round a link, as on every steam-trawler: The line will then go forward, where it is easiest to heave up the seine clear of the propeller; but also during the heaving-in you must have the wind (or the current) starboard, so that the vessel may drive clear of the seine; otherwise it will come under the keel.

5. In Spitzbergen, where I stayed for some time this year together with *Dr. Hjort*, and where we employed a little otter-seine of my own construction, the whole seine, with the exception of the headrope and ground-rope, was once lost, because the rich laminaria-vegetation tore away the net from the ropes, the plants beginning to tear the meshes to pieces close to the boards where the arms begin. I believe that this may be avoided by running a strong string through the meshes from the headrope to the groundrope on either arm, at the foremost end of the same. This is a difficulty I never before met with.

6. Since I wrote about these otter-seines, in 1898, I have tried to use real English trawls in the same way, viz. in crow-foot and with a single tow-rope, so that both boards are hauled on board in the same place, not in two davits, one for either board, as the steam-trawlers do. I have done this in order to try to fish with greater speed, as the trawls have larger meshes and, consequently, can stand it, and thereby catch more, particularly larger, fish. These experiments have succeeded beyond expectation. I have employed trawls from England, whose head-rope is c. 50 foot long, and for these I used boards weighing 170 Danish pounds (85 Kilo) each; the latter were 4 feet 10 inches long and 2 feet 6 inches high. They have been manoeuvred from the Biological Station's steamship "*Sallingsund*" (c. 100

indicated H. P.), just as the small otter-seines, and they fish exceedingly well — though of course not the smallest species of animals. Moreover, they offer the advantage that they do not go to pieces so easily as the seines on account of the stout threads in the meshes. I have no doubt that, with some practice, they may be employed on the greatest depths of the ocean. When the tow-rope, shortly after the heaving-out, is hauled up in the snatch-block astern, you may veer out as much rope as you want, without endangering the propeller. This cannot be done with the common steam-trawl with two lines; here the ship must constantly be clear to turn away from the lines, and this is very difficult on great depths, because you run the risk of getting the trawl foul. As I have before pointed out, we do not know any universal fishing apparatus which catches everything, and under all conditions. But the small otter-seines have already many excellent qualities, of which the most significant is their capacity for catching the smaller, but quick animals; moreover, they are exceedingly well calculated to be used from steam-launches, and the like, on lower water. When we have these seines and, besides, the said larger English otter-trawls, we can do much. They are absolutely unfit, however, to be used on a stony bottom; there we must employ fixed apparatus, traps, hooks, etc., if we want to catch many fish. When we use hooks, however, we must be careful *that the hooks themselves do not lie on the bottom*; for then echinoderms and crustacea generally take the bait, before the fishes can get at it. This may happen both on a soft and on a hard bottom.

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By
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